Notes on some Points connected with the Progress of Astronomy during the Past Year.

Discovery of Minor Planets.

The following seven minor planets were discovered in the year 1887:—

No.	Name of Planet.	Date of Discovery, 1887.	Discoverer.	Place of Discovery.
265	Anna	Feb. 27	Palisa	Vienna
266	Aline	May 17	,,	,,
267	Tirza	May 27	Charlois	Nice
268	Adorea	June 9	Borrelly	Marseilles
269		Sept. 21	Palisa	Vienna
270	Anahita	Oct. 8	Peters	Clinton
271	Penthesilea	Oct. 16	Knorre	Berlin

Minor planets Nos. 262 and 263, both discovered by Herr Palisa on Nov. 3, 1886, have been named *Valda* and *Dresda* respectively.

The Comets of 1887.

The following six comets have been discovered during the year 1887; brief notices of each are given in the order of their discovery.

Comet I., 1887.—The great Southern Comet, first seen with the naked eye at several places in the southern hemisphere, in the third week of January. Its appearance resembled that of Comet I., 1880, and it is one of a group of comets, all with short perihelion distances, of which other members are known as 1843 I., 1880 I., and 1882 II., and among which may possibly be included Pogson's Comet of 1872, and the one visible at the time of the solar eclipse, 1882, May 16.

Its appearance is described at Cape Town as presenting no observable condensation, and having a band of light 35° long, narrowing towards the Sun. The observations are, in con-

sequence of the absence of any observable nucleus, very rough, and extend over such an inconsiderable interval of time that the determination of the orbit (which has been attempted by Mr. Finlay and Dr. Oppenheim) is very unsatisfactory, but it possesses sufficient exactness to show the similarity of the elements with those of the comets mentioned above.

The comet was not seen in the northern hemisphere; a suspicious observation, recorded by Mr. Lewis Swift, of Rochester, does not appear to refer to this comet.

Comet II., 1887.—On January 22, a faint comet was detected by Mr. Brooks, of Phelps, N.Y., in the constellation *Draco*, and which passed through its perihelion about the middle of March, but at a considerable distance from the Sun (1·633), and consequently, though observations were possible for a considerable period, it never attained any great brilliancy. The comet was observed as late as April 23, when it possessed a theoretical brilliancy of less than one-half that which it had at the time of discovery. The observations are well represented by a parabola, and very approximate elements are given by Dr. Oppenheim, *Ast. Nach.*, No. 2,780.

Comet VIII., 1886.—This comet was discovered by Mr. Barnard, of Nashville, on the following evening, January 23, but as the perihelion passage occurred in the previous November it is referred in the catalogues to that year. The brightness was rapidly diminishing at the time of discovery, but observations were continued till the middle of May, and as in the case of the last comet, these observations are well represented by a parabola.

Comet III., 1887.—Also a parabolic comet discovered by Mr. Barnard on February 16, 1887. This comet was very faint and offered no central condensation, and does not appear to have been very frequently observed. Very approximate elements are given by Dr. Oppenheim in *Ast. Nach.*, No. 2,777.

Comet IV., 1887.—Was also discovered by Mr. Barnard, on May 12, at a considerable southern declination. This comet had a faint tail preceding, and a faint nucleus, estimated at Algiers to be of the twelfth magnitude. The comet was moving rapidly to the north so as to become an easy object in northern observatories, and throughout the month of June and part of July could have been observed with meridian instruments. The gradual diminution of the light prevented observations after the middle of August. The deviation from parabolic motion is probably very slight, but the definitive discussion of the orbit has been undertaken by Dr. Muller, of the McCormick Observatory, Virginia.

Comet V., 1887.—Better known as the reappearance of Olbers's Comet of 1815, the return of which was to be expected from the careful computations of Dr. Ginzel. The comet was first seen by Mr. Brooks on August 24, though its identity with that of Olbers was not then suspected. It was tolerably bright, with traces of nucleus and tail.

The extensive ephemerides which Dr. Ginzel had prepared

with the view of aiding its discovery and recognition showed at once that the earliest observations corresponded to a true anomaly of about $-40°$, and, therefore, that the perihelion passage would occur early in October, and that consequently the most probable period given by the calculations was only about 290 days in error, or less than half the amount which Dr. Ginzel thought possible. The period is about 72·6 years, but the definitive determination of the elements will be still further pursued by Dr. Ginzel.

The greatest brilliancy of the comet was reached about Oct. 10, and though the light is now only about one-third of that the comet had at the date of its discovery, it is to be hoped that it is still within observation of some of the larger telescopes.

W. E. P.

The Transit of Venus, 1882.

The Committee appointed by the Government to superintend the Transit of *Venus* 1882 expeditions has presented its report, which, with the exception of a short introduction enumerating the stations selected by the Committee, the *personnel*, and acknowledging obligations to institutions, Governments, and individuals who had rendered assistance, consists entirely of the discussion of the observations of contact by Mr. Stone, the Directing Astronomer.

In addition to the observations made by the Government expeditions to Madagascar, Barbadoes, Jamaica, Bermuda, and New Zealand, the report includes observations made at Mauritius (1 obs.); Durban, Natal (1); Cape of Good Hope (10); Strait of Magellan (3); Cambridge, Mass. (2); Kingston, Canada (2); Ottawa (2); Cobourg (1); Winnipeg (1); Hobart (1); Melbourne (2); Wentworth, N.S.W. (1); New Zealand (14); so that for the internal contact at *ingress* there are 24 observations and for the same phase at *egress* 32 observations.

For *ingress* four more or less distinct phases, spread over a minute of time, appear to be recognised. The second of these phases, corresponding to a distance of the centres of the Sun and *Venus* of $941''\cdot4$, is believed to be identified in eleven reports, and these give for the solar parallax

$$8''\cdot874 \pm 0''\cdot081.$$

The 24 observations of the third phase, corresponding to a distance of centres of $939''\cdot8$ (which was the principal phase according to the instructions issued by the Committee), give for the mean solar parallax

$$8''\cdot823 \pm 0''\cdot023.$$

For the *egress* two phases appear to be recognised—

(1) Haze or shadow.

(2) Limbs obscured, or geometrical contact.

But, at many of the stations, only a single time had been given as that of internal contact, and it became therefore necessary to select from the two times given at the other stations a time of internal contact to be combined with the times recorded for internal contact at the stations where only one time was given.

Three solutions have therefore been given—

First, by taking the times recorded for "haze or shadow" for combination with the single recorded times for internal contact at the other stations the resulting value is

$$\pi = 8''\cdot827 \pm 0''\cdot050.$$

Secondly, by taking the times recorded for "limbs obscured, or geometrical contact," for combination with the single recorded times for internal contact the resulting value is

$$\pi = 8''\cdot882 \pm 0''\cdot043.$$

Thirdly, by taking the mean of the two recorded times as that which best represents, in the mean, the time of internal contact which would have been assigned had the observers at all stations restricted themselves to a single time of internal contact the result obtained is

$$\pi = 8''\cdot855 \pm 0''\cdot036.$$

And this is considered in the report as the best result obtainable from the *egress* observations.

When the results from *ingress* and *egress* are combined, the effects of any small outstanding errors of relative differences in R.A. and N.P.D. are sensibly eliminated, and the resulting value is

$$\pi = 8''\cdot832 \pm 0''\cdot024.$$

The report contains no details of time observations or of determinations of longitudes. And, as the results of some new and accurate longitudes are here made known, it is to be hoped that the details may be soon published. The report is silent on the subject.

The Total Solar Eclipse of August 19, 1887.

The total solar eclipse of August 19, 1887, will long be remembered as an occasion on which the most extensive preparations on the part of observers were only attended by the most widespread disappointment. At eight German stations, thirteen Russian, and one Japanese, representing more than double this number of observers, the sky was quite cloudy during

totality. Fine weather, apparently quite local, favoured only the following stations:—

(1) A village on the Moscow railroad, where Prince Gagarin photographed the corona.

(2) Elpatievo Narischkine (longitude $2^h\ 32{\cdot}5^m$ E., latitude $56°\ 58'$ N.), where Mr. Il. Urech made eye-observations of the corona and prominences, of which four were seen.

(3) Petrowsk, where Professor Glasenapp obtained seven sketches and two photographs of the corona, thin cloud preventing his proposed search for *Vulcan*. Photographs of the corona were also obtained by Kowalsky and Tatschaloff, of St. Petersburg, and Stanoiewitsch, of Meudon, and of the spectrum by Professor Kononovitsch, of Odessa.

(4) Jurjewitz, where in bad weather Dr. Niesten made a drawing of the corona and secured six good photographs; and Mr. Karelin with his 6-inch portrait lens also obtained a very good photograph.

(5) At Mount Blagodat, in the Urals, Dr. Handrikof made some good drawings of the corona and prominences.

(6) Krasnojarsk, where sketches and photographs were obtained by Chamontoff and party.

(7) At Irkutsk a good photograph of the corona was obtained.

(8) In Japan (Echigo) three good photographs of the corona were obtained by Professor Jarai and Mr. M. Sugiyama.

A very complete organisation, under Professor Struve's direction, of stations on the north and south boundaries of totality for determining the ratio of the diameters of the Sun and Moon by observations of the second and third contacts ended only in failure owing to the weather.

The drawings of Dr. Handrikof and the Japanese photographs agree more closely than previous results would lead us to expect. No particulars of orientation are given, however, and the internal evidence not even being consistent, some assumption must be made for the interpretation. The most plausible seems to be that Dr. Handrikof's first drawing (of Baily's beads just before totality) was made with the naked eye, and is erect; while the subsequent drawings of the corona were made with a telescope, and are inverted. The top of the photographs and first drawing then correspond to the north point, and not to the vertex. If this assumption be correct, the coronal extension was greater in the southern hemisphere than in the northern, the principal ray extending from the south-west limit for at least a diameter, as shown in both photographs and drawing. A long though rather low-lying group of prominences was situated at the base of this ray. A fine prominence is shown almost due east, and three others in the north-east. On the east of the Sun are two of the well-known conical masses, composed of rays curving towards each other.

As regards physical observations, nothing has yet been published, except that the single photograph of Prof. Kononovitsch shows the coronal green line.

Sir George Airy's Numerical Lunar Theory.

This work is offered by its distinguished author not as a complete theory of the motions of the Moon, but rather as an examination of Delaunay's lunar theory, as tested by the substitution of numbers for symbols throughout. Delaunay, in his great work, expresses the value of the Moon's longitude and latitude, and also the reciprocal of the radius vector, analytically in terms of certain constant quantities which can only be determined by observation, such as the ratio of the mean motions of the Sun and Moon, the mean eccentricity and inclination of the Moon's orbit, the eccentricity of the Sun's orbit, and the ratio of the Moon's mean distance to that of the Sun. Besides these quantities there are two others which, although they are capable of being found by theory, and have been actually so found with a considerable degree of accuracy, are practically found from observation extending over a long interval of time. These latter quantities are the mean motions of the Moon's perigee and node respectively.

Now, it is evident that if Delaunay's symbols be replaced by the numbers for which they stand, both in the coefficients of the several equations and in the rates of motion of the various arguments, the numerical expressions so formed ought to satisfy the three differential equations of motion identically, provided that Delaunay's solution be sufficiently accurate.

The first part of the present work consists in the carrying out of the above-mentioned substitutions in the differential equations. The operations are necessarily of very great length, and are arranged in the orderly manner to be expected from the author, and every care appears to be taken to ensure accuracy. Notwithstanding this, the author is greatly disappointed with the results. Instead of the equations being nearly satisfied, as was expected, very large discordances showed themselves, more especially in the two equations relating to motion parallel to the plane of the ecliptic, and the author is led to fear that the discordances may be caused by errors on his own part.

It has been pointed out, however, in a paper in the *Monthly Notices* for June 1883, that Delaunay has found the analytical expression for the reciprocal of the radius vector with a far less degree of accuracy than in the case of the Moon's longitude and latitude. In the two latter coordinates he has taken into account generally the terms of the 7th order, and in cases where the convergence of the series is found to be slow, he has included terms of the 8th and 9th orders. In the reciprocal

of the radius vector, however, he has confined his attention to the 5th order. Consequently, while the coefficients of the inequalities in longitude and latitude as found by him are generally only a small fraction of a second in error, the inequalities in the reciprocal of the radius vector are not found with sufficient precision to give even the parallax itself with all the accuracy which is desirable. The neglect of Delaunay of all terms in the parallax of orders higher than the 5th is quite sufficient to account for the discordances noticed by the author, without supposing his own work to be in error.

The second part of the work has for its object to correct the numerical values of the coefficients of the several inequalities as found from Delaunay, by giving to each coefficient an indeterminate variation, and then supposing, as we may do, that the powers of such variations above the first may be neglected, by forming the corresponding expressions for the additional terms thus introduced into the several equations, and thus obtaining a great number of simple equations between those indeterminate variations, by the solution of which their values may be found. This part of the work is far less completely done than the former.

The final equations for the correction of the coefficients are confined to the first 100 arguments in each of two series, the first of which belongs to motion parallel to the plane of the ecliptic and the second to motion perpendicular to it.

To make the work complete many more of the equations should be taken into account.

Since the errors affecting Delaunay's coefficients of parallax are comparatively large, it will be necessary to determine the factors by which these errors are multiplied in the equations of condition with a much greater degree of accuracy than is required in the case of the factors by which the errors of the coefficients of longitude and latitude are multiplied in the same equations. Otherwise it will not be possible to deduce these last-mentioned errors from the equations with the requisite degree of precision.

This has been already pointed out in the paper above referred to, and, as is there stated, it will be necessary to take special precautions in order to determine with accuracy the corrections of the assumed coefficients in the inequalities of longitude which have long periods. On the other hand, in the case of inequalities whose periods are not greater than about one half the Moon's periodic time, the equations for finding the corrections required by the coefficients of longitude and reciprocal of radius vector are very distinct from each other, so that each of these corrections may be found by means of a large divisor, and therefore the results will be little affected by small errors or omissions in the calculations.

Thus the solutions given by Sir George Airy in his Section X. for the equations which admit of large divisors are fairly satisfactory.

It is quite otherwise in the case of inequalities of radius vector and longitude, the periods of which are either nearly equal to the Moon's periodic time, or are much greater than that period. In both these cases, the corrections required have to be found by means of a very small divisor, so that a small error of calculation or of omission will be much magnified in the result.

In these cases the author simply adds together the pair of equations from which the corrections of the corresponding coefficients of longitude and radius vector are to be determined, and thus forms one final equation, and he is driven to supply the second equation by the wholly inadmissible assumption that the correction required by the coefficient of the reciprocal of radius vector is twenty-five times as great as that required by the corresponding coefficient of longitude.

It would be more accurate to assume that the errors of Delaunay's equations of longitude are zero, and to use the single final equation obtained in the way just mentioned in order to obtain the corrections required by the corresponding coefficients of parallax.

It may be remarked that the coefficients of parallax thus found agree very well with those given in the paper in the *Monthly Notices* of June 1883, which has been already mentioned.

J. C. A.

Professor Auwers's Investigation of the Sun's Diameter.

A very complete investigation of the value of the important constant of the Sun's diameter, obtained by meridian observations, has been made by Professor Auwers, and published in the *Sitzungsberichte* of the Berlin Academy.

The results for the horizontal and vertical diameters are derived from a discussion of the following observations: (1) A long series of thirty-three years' observations made with the Greenwich transit circle, 1851 to 1883; (2) Washington transit circle observations, 1866 to 1882; (3) Oxford (Radcliffe) observations, 1862 to 1883, with the exception of the years 1877 to 1879; and a series of Neuchatel observations, 1862 to 1883.

In discussing the Greenwich observations Professor Auwers gives in two tables the mean annual correction to the horizontal and vertical diameters for each observer from 1851 to 1883. The personal equations are determined, first, on the supposition that the Sun's diameter may be variable; and, finally, on the view that the mean annual diameter is constant, and that the personal equations may be liable to change. The personal equations are referred to the mean of the four observers, Dunkin, Ellis, Criswick, and Carpenter, who made the larger part of the observations, with the following results:—

Horizontal diameter	32′ 2″·48	3114 Observations.
Vertical diameter	32 2·00	3289 ,,

The results of the Greenwich observations referred to the mean observer give—

Horizontal diameter	32′ 2″·01
Vertical diameter	32 2·73

A reduction of the heliometer observations made by the German Transit of *Venus* expeditions gives a value for the Sun's diameter of 31′ 59″·12. These observations were made with object-glasses of about 3 inches diameter, and the results do not differ materially from those made with the Königsberg 6-inch heliometer. The author therefore assumes provisionally the value 31′ 59″·12 as an absolute determination of the solar diameter with which to compare the Greenwich results. And in an interesting table he gives the personal equations for the two diameters of the 67 Greenwich observers, their absolute errors, and the differences of the two observed diameters. It is significant that all the errors for both horizontal and vertical diameters are positive, and in the column H−V it is equally noteworthy that the sign in the majority of cases is negative.

The Washington observations are discussed in a similar manner to those of Greenwich, and yield the following results:—

Horizontal diameter	32′ 2″·41	1321 Observations.
Vertical diameter	32 2·65	1297 ,,

A similar determination of the personal equations and absolute errors of the 15 Washington observers is made as in the case of Greenwich, and with a similar result; all the errors for both horizontal and vertical diameters are positive.

The final results obtained for the mean values of the Sun's (assumed circular) diameter, from each series of observations, are—

Greenwich	32′ 2″·36	Oxford	32′ 3″·19
Washington	32 2·51	Neuchatel	32 3·27

The conclusion from this discussion arrived at by Professor Auwers is that the determination of the Sun's diameter by meridian observations is largely affected by personal equations, which may amount to 4″ or 5″; and further, that for the investigation of any ellipticity in the Sun's disk, it would be preferable to employ the heliometer.

The second portion of Professor Auwers's paper is devoted to the subject of the alleged annual variation of the Sun's diameter; the conclusion arrived at being that such variation has no real existence, and that the apparent differences are due in a great measure to the influence of temperature on the instruments.

This investigation of Professor Auwers is of very high

importance, as it gives us the most reliable value of the solar diameter which the best meridian observations are capable of affording.

The Catalogue of the Paris Observatory.

On becoming Director of the Paris Observatory in 1854, Le Verrier resolved to undertake the re-observation of Lalande's catalogue of 47,390 stars; and as he considered it of primary importance that at least three observations in both right ascension and declination should be secured, the task proposed was of a gigantic character worthy of that illustrious astronomer.

Up to the year 1879 only about one-third of the necessary observations had been secured, including the previous observations made since 1837 under the direction of Arago, and the average number of meridian observations made annually was about 6,000 to 8,000. Since then the instruments of the observatory have been increased by the Bischoffsheim Meridian Circle, and through the active directorship of Admiral Mouchez the observing staff has been augmented, so that for the past seven or eight years the number of observations secured annually towards the preparation of the catalogue has amounted to the remarkable number of 25,000 to 28,000.

It was not considered desirable to delay publication until the whole of the stars had been observed, and therefore the first part now publishing is limited to stars observed up to the year 1881, which form about three-fourths of the whole number: the observations subsequent to 1881 will be published in a separate volume.

The first instalment of this important catalogue has just been published in two handsome volumes, one being devoted to the catalogue and the other to the individual observations. The portion of the catalogue published consists of stars in the first six hours of right ascension observed during the years 1837 to 1881. It contains 7,245 stars, and represents 80,000 observations in both elements.

As the observations extend from 1837 to 1881, they are divided into three distinct periods—1837–1853, 1854–1867, and 1868–1881—the observations of each period being reduced to their mean epochs respectively, 1845·0, 1860·0, and 1875·0, thus forming three separate catalogues. All the stars are arranged in the catalogue in the order of their right ascension for 1875·0.

The catalogue gives the number of observations in each of the three periods, the mean date, the R.A., and N.P.D. for each epoch, precessions for 1875·0, and comparison of each catalogue 1845·0, 1860·0, and 1875·0 with Lalande.

As a very large proportion of the observations were made with the transit instrument and the mural circle (meridian

circles having been mounted only in 1863 and 1877), it has resulted that in many cases the number of observations of a star secured in right ascension is disproportionate to the observations in N.P.D. Many of such stars will be re-observed and the results published in a supplementary catalogue.

The reduction of the observations has been conducted under the superintendence of M. Gaillot, who contributes an interesting discussion of the value of the results.

The introductory chapters contain a comparison of the Paris Catalogue with Auwers's re-reduction of Bradley. M. Bossert furnishes a valuable investigation of the proper motions of 374 stars in the catalogue, and he also supplies a long list of errors in Lalande.

The importance of this catalogue to astronomers cannot be over-estimated, and the Paris Observatory is to be congratulated on this indication of the eminently satisfactory manner in which the work has been carried out.

The Dunsink Catalogue of 1,012 *Southern Stars.*

The sixth part of the Astronomical Observations made at the Dunsink Observatory is devoted to a catalogue of the mean places of 1,012 Southern Stars made with the meridian circle, which has been prepared by the Assistant Astronomer, Mr. Rambaut.

Nearly all the stars are contained in the *Southern Durchmusterung Belt* — 2° to — 23° declination, which had been suggested by Prof. Schönfeld and Prof. Peters as needing observation.

The observations were commenced in September 1881 by Dr. Dreyer, and continued by him till May 1882. Mr. Rambaut's observations comprise the period November 1882 to September 1885. The standard stars employed are those of the Berlin *Jahrbuch*, and the observations are reduced to Auwers's system. Most of the stars appear to have been observed only once or twice, and the observations available for the calculation of the probable error are few. A systematic difference is suspected in the right ascensions of the two observers, inasmuch as Dr. Dreyer observed with the eye and ear method, and Mr. Rambaut with the chronograph. The catalogue gives the mean right ascensions and declinations, with the annual precessions, for the epoch 1885·0, the *Durchmusterung* magnitudes, the mean epoch and the number of observations. The separate results for all the observations are contained in the volume.

Heliometer Determination of the Relative Places of the Principal Stars of the Pleiades.

Dr. Elkin has published in the first volume of the *Transactions of the Astronomical Observatory of Yale University* an important investigation of the relative positions of the stars of the *Pleiades* group made by means of the Repsold heliometer of that observatory, which has an object-glass of about 6 inches aperture and rather more than 8 feet focal length.

Taking into consideration the fact that the heliometer determines the relative distance and position-angle of two stars by essentially different means and with considerably different accuracy, the probable error of a distance being much less than of a position-angle, the author resolved to make his determination rest as far as possible on measurements of distance only.

The plan adopted was as follows:—"Near the outer limits of the group four stars were chosen so that nearly the entire group would be enclosed as symmetrically as possible by the quadrilateral they formed, and as their relative positions were to be determined with the greatest possible accuracy, they were taken within direct measuring range of the heliometer. The determination of the place of each star in the group was then to consist of measurements of its distance from each of these four reference points, each such measure giving, it will be seen, an equation involving corrections to an assumed place of the star and the scale value of the heliometer, we would thus have four equations with three unknown quantities, all of which in case the star lay well within the quadilateral could be determined with accuracy." The plan of the work was subsequently modified, and the author concluded to carry out in addition a plan of triangulation similar to Bessel's—namely, measurements of distance and position-angle from η *Tauri* (*Alcyone*), the central star of the group.

The work, therefore, consists of two independent triangulations, one resting upon the four stars enclosing the group, and the other upon the central star *Alcyone*. Unfortunately the two triangulations were not executed simultaneously, the mean epoch of the second falling about a year later than that of the first.

All the observations were made with an eyepiece magnifying 330 times, and with a direct-vision reversing prism placed before it; by means of screens the two stars were reduced to within one-half magnitude of equality. A complete discussion is given of the division errors of the scales, the determination of the scale value, and reduction of the measures of distance and position-angle. Paragraph 8 is devoted to the measures of the distance and position-angles of the *Pleiades* stars from *Alcyone*, and gives a table of the differences of Right Ascension and Declination from that star, and the absolute places of 68 stars for

the epoch 1885·0. Paragraph 9 gives the measures of distances of the *Pleiades* stars from the four stars of the fundamental quadrilateral, with their complete reduction.

In paragraph 11 the author gives the comparison and combination of the two measurements and the deduction of the definitive results. From the discussion it appears that for all distances the probable error is sensibly the same; but the magnitude of the star has had a large effect, and the same thing is noticeable in the probable error of the position-angles; thus—

Magnitude.	Probable Error of one Observation of Distance.	Probable Error of one Observation of Position-angle.
3·0 to 7·5	±0″·148	±0″·177
7·6 ,, 8·1	0·169	0·236
8·2 ,, 8·8	0·223	0·289
8·9 ,, 9·2	0·276	0·378

From this it appears that the mean ratio of probable errors is 0·77, or the relative weight of one observation of position-angle is but 0·59 of that of one of distance. The comparison of the two triangulations arranged in magnitude groups indicates that the measures of the four quadrilateral stars from *Alcyone* which serves to unite the two systems are still capable of improvement. The final results are given in a catalogue of 69 stars, giving the right ascension, declination, precession, and secular variation for the epoch 1885·0.

The following sections of the memoir contain a discussion of the Königsberg heliometer measures on the view that the temperature coefficient of the screw value used by Bessel was erroneous; these observations are therefore newly reduced and brought up to 1885·0 for comparison with the Yale results. This comparison is well exhibited by a chart of 32 stars of the *Pleiades*, showing the apparent displacements that result. A remarkable fact is brought out in this comparison—namely, that for the six stars giving the largest values Y–K there is a community of direction and amount; thus:—

Star.	Displacement in R.A.	Displacement in Decl.	Resultant.
14	−1·43	+2″·15	2″·52
17	−2·67	+1·28	2·76
21	−1·31	+1·32	1·78
26	−1·80	+1·16	2·01
35	−1·32	+2·23	2·54
36	−1·91	+1·19	2·12

—the inference being that these six stars do not belong to the group, but are projected on it. Of the remaining 26 of the

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32 stars, six stars have an easterly motion, while 20 move towards the west.

Dr. Elkin's valuable memoir concludes with a comparison of his results with the micrometrical determinations of the *Pleiades* made by Wolf at Paris and by Pritchard at Oxford. The deduction from this is, that the use of the filar micrometer for such large distances as those under consideration is likely to be accompanied with considerable casual error and, unless great care be taken, with large systematic error; and the conclusions as to the relative motions in the group advanced in the two memoirs referred to are not supported by the Yale results.

The International Astrophotographic Congress, 1887.

The Congress which assembled at the Paris Observatory on April 16, in response to the invitation of the Académie des Sciences, was attended by the following 56 delegates and representatives of different countries:—

France (20). MM. Baillaud, Bertrand, Bouquet de la Grye, Cloué, Cornu, Faye, Fizeau, Gautier, Paul Henry, Prosper Henry, Janssen, Laussedat, Liard, Loewy, Mouchez, Perrier, Rayet, Tisserand, Trépied (Algiers), and Wolf.
England (8). MM. Christie, Common, Gill (Cape Colony), Knobel, Perry, Roberts, Russell (Australia), and Tennant
Germany (6). MM. Auwers, Krueger, Lohse, Schoenfeld, Steinheil, and Vogel.
Russia (3). MM. Donner, Hasselberg, and Struve.
Holland (3). MM. Bakhuyzen, Kapteyn, and Oudemans.
Austria (2). MM. Eder and Weiss.
Sweden (2). MM. Dunér and Gyldén.
Denmark (2). MM. Pechüle and Thiele.
Belgium (1). M. Folie.
Italy (1). M. Tacchini.
Spain (1). M. Pujazon.
Portugal (1). M. Oom.
Switzerland (1). M. E. Gautier.
America (3). MM. Elkin, Peters, and Winterhalter.
Brazil (1). M. Cruls.
Argentine Republic (1). M. Beuf.

[Of the above, Messrs. Common, Knobel, and General Tennant were delegates from this Society, and this is in substance the report made by them to the Council on their return.]

The Conference was opened by M. Flourens, the Minister for Foreign Affairs, who expressed a cordial welcome to the members in the name of the French Republic, and assured them of the

sympathy and co-operation of the Government in the work they might decide to undertake.

The Conference was conducted under the following Bureau :—

Honorary President : Admiral Mouchez.
Acting President : M. Otto Struve.
Vice-Presidents : MM. Auwers, Christie, and Faye.
Secretaries : MM. Bakhuyzen and Tisserand.
Assistant Secretaries : MM. Dunér and Trépied.

The following general resolutions, which had been printed in a provisional programme, were first taken into consideration and adopted *unanimously* :—

I. The progress made in astronomical photography demands that the astronomers of the present day should unite in undertaking a description of the heavens by photographic means.

II. This work shall be carried out at selected stations, and with instruments which should be identical in their essential parts.

III. The principal objects are : α. To prepare a general photographic chart of the heavens for the present epoch, and to obtain data which will enable us to determine with the greatest possible accuracy the positions and the brightness of all the stars down to a given magnitude (the magnitudes being understood in a photographic sense to be defined). β. To be able to utilise in the best way, both at the present day and in the future, the data obtained by photographic means.

To facilitate the work of the Congress it was decided that a Technical Committee be appointed to consider and report upon the form and size of the instruments to be used, and the least magnitude of stars which it was desirable to photograph on the plates. This Committee consisted of MM. Auwers, Bakhuyzen, Christie, Common, Dunér, Fizeau, Gill, Paul Henry, Janssen, Kapteyn, Loewy, Peters, Rayet, Roberts, Struve, Tacchini, Thiele, Vogel, and Weiss.

The Committee met on April 18 under the presidency of M. Struve, with M. Loewy as secretary. It was unanimously resolved that the *refractor* was the best form of instrument to be employed, and that the dimensions of the photographic equatorial at the Paris Observatory were the most suitable. It was also unanimously resolved that stars be photographed to the 14th magnitude. This decision of the Committee was in a great measure guided by a statement made by M. Paul Henry, that with his telescope of $0^{m}\cdot33$ aperture it required an exposure of about 15 minutes to obtain images of stars of about the 14th magnitude, and that to obtain one magnitude lower on the plates the exposure would be $2\frac{1}{2}$ times longer.

The actual recommendations of the Committee finally adopted by the Conference are—

1. The instruments employed shall be exclusively refractors.
2. The stars shall be photographed to the 14th magnitude inclusive, this magnitude being expressed provisionally on the scale actually in use in France, and with the reservation that its photometric value shall be definitely fixed later.
3. The aperture of the object-glass shall be $0^{m}\cdot33$, and the focal distance about $3^{m}\cdot43$, so that $1'$ of arc is represented approximately by $0^{m}\cdot001$.

With regard to the above resolutions it should be remarked that M. Steinheil insisted, that in order to have identical instruments, great care should be taken in the selection of the glass, and that the Conference ought to indicate not only the quality to be used, but also the manner in which the objective should be constructed.

The Congress decided to discuss the details of the work in two sections—one *Astrophotographic*, under the presidency of M. Janssen; and the other *Astronomical*, under M. Auwers.

Astrophotographic Section.

The recommendations of this section were accepted *unanimously* by the Congress. They are as follows :—

1. Directors of observatories will be free to have their object-glasses made by any optician they desire to employ, provided they comply with the general conditions laid down by the Congress.
2. The corrections for spherical and chromatic aberration of the object-glasses shall be calculated for rays in the neighbourhood of G of Fraunhofer's scale.
3. The above resolution with regard to the corrections for spherical and chromatic aberration of the object-glasses shall be understood thus: the minimum focal distance shall be that of a ray near G, so as to secure the maximum sensitiveness on the photographic plates.
4. All plates shall be prepared according to one formula to be subsequently determined.
5. A permanent supervision shall be kept over the plates with regard to their relative sensitiveness to different rays.
6. The questions of the preservation and reproduction of the photographic plates cannot be settled now, and it is desirable to refer them for investigation to a special committee.
7. The same course is adopted for the question of the determination of the photographic magnitudes of stars.
8. The object-glasses shall be constructed in such a manner that the available field shall have a radius of at least 1°.
9. In order to eliminate any spurious stars, and to guard

against the inconvenience of minute specks on the plates, two series of plates shall be taken for the whole heavens.

10. The two series of plates shall be so taken that a star situated at the corner of a plate of the first series shall be as near as possible to the centre of a plate of the second series.

With regard to the preparation of the photographic plates, the opinion was strongly expressed upon the great desirability of all the plates being made by the same manufacturer, but this was considered impracticable. MM. Henry, Cornu, and Eder had made many experiments with plates made by different manufacturers, and they were agreed that the differences they found were, as a rule, in sensitiveness only, and not in the maximum sensibility to particular rays.

On this subject the following proposition was made by MM. Dunér, Eder, Hasselberg, Lohse, Tacchini, Vogel, and Weiss: "With regard to the selection of the photographic plates, we suggest that, in addition to the experiments which will be made with ordinary gelatino-bromide of silver plates, there should also be some experiments with plates rendered sensitive to the less refrangible rays of the spectrum by means of colouring matters."

These questions, as well as other suggestions made to the Conference, have been dealt with since by the Permanent Committee.

Astronomical Section.

The recommendations of this section, which were adopted by the Congress, were as follows:—

1. Besides the two plates which should give all stars in the chart of the heavens down to the 14th magnitude, there shall be taken another series with a shorter exposure, in order to secure greater precision in the micrometric measurement of the reference stars and to render possible the construction of a catalogue.

2. The supplementary plates destined for the construction of the catalogue shall contain all stars to the 11th magnitude inclusive. The Permanent Committee shall regulate the proceedings so as to ensure that this condition be fulfilled.

Dr. Schoenfeld estimated that the total number of stars down to 11·5 magnitude would be about $3\frac{1}{4}$ millions.

3. Each photographic plate intended for the catalogue shall be accompanied by all the data necessary for orientation and for the determination of its scale value; as far as possible these data should be found inscribed on the plate itself.

Every plate of this kind shall bear a copy, carefully centred, of a system of reference lines derived from a *réseau*, and intended to eliminate the errors which might be produced by an after distortion of the sensitive film.

Other questions relating to the data contained on the plates will be decided by the Permanent Committee.

4. In the construction of the plates destined to form the chart, the number of auxiliary comparisons intended for the

verification and reduction of the plates shall be reduced to a minimum.

5. The tubes of the photographic instruments shall be made of the most suitable metal for securing an unvarying focal plane, and they shall carry a scale for the determination and adjustment of the position of the plates.

6. The selection of fundamental stars, as well as the question of the formation of a provisional catalogue for the chart of the southern hemisphere, is referred to the Permanent Committee.

7. The question of the mode of measurement, and of the conversion of the numbers obtained into Right Ascensions and Declinations for the equinox 1900, is referred to the Permanent Committee.

The Committee shall in the first place take into consideration the employment of measuring instruments capable of giving, as may be desired, rectangular or polar co-ordinates, and based upon the simultaneous use of scales for long distances and a micrometer eyepiece for the subdivisions of the scale.

It will be seen that the Congress confined its resolutions as far as possible to general principles, leaving the details to be settled by the Permanent Committee. The opinion was expressed that it might be two years before the work could begin generally, and during that time it was reasonable to expect many photographic and optical improvements to be made.

The Congress resolved that the Permanent Committee should be formed on the following principles :—

"The Permanent Committee shall consist of two categories of members.

"(1) All Directors of observatories who will take practical part in the work.

"(2) Members not necessarily taking a direct share of the work."

It was resolved that the second category should be limited to eleven members. The following were elected :—

Christie	Janssen	Tacchini
Dunér	Loewy	Vogel
Gill	Pickering	Weiss
Henry (Prosper)	Struve	

On the subject of other branches of celestial photography than those pertaining to the chart the following resolution was adopted by the Congress :—

"The Congress deems it necessary that there should be a special committee devoted to other branches of astronomical photography than those relating to the chart, considering their importance and the relation which it is expedient to establish between these branches of research. This committee should

place itself in communication with the committee of the chart. The Congress expresses the hope that MM. Common and Janssen would undertake the fulfilment of this wish."

This practically terminated the work of the Congress.

The Permanent Committee met on April 26, and resolved that the Bureau should consist of one President, five Members, and three Secretaries. These would constitute the executive body. The following were elected :—

President : Mouchez.
Members : Christie, Dunér, Janssen, Struve, Tacchini.
Secretaries : Gill, Loewy, Vogel.

It was decided that their proceedings and any researches instituted by them should be published, and it was intimated by Admiral Mouchez that the Académie des Sciences would generously co-operate with them for that purpose.

Summary.

All the resolutions of the Congress have been passed either unanimously or by very large majorities. They may be briefly summarised :—

I. A photographic chart of the heavens containing all stars down to the 14th magnitude is to be at once undertaken, the plates to be in duplicate.

II. A second series of photographs with shorter exposure, to include stars of the 11th magnitude, is to be made concurrently with the first, for the purpose of forming a catalogue and to determine fundamental positions in the first series.

III. The photographic plates are to be prepared from the same formula.

IV. The photographic telescope is to be identical in all essential particulars with that used by the brothers Henry at the Paris Observatory.

The Government of the French Republic has expressed its intention of taking part in the work, and the necessary instructions have been given to the four Observatories of Paris, Toulouse, Bordeaux, and Algiers, for which photographic telescopes are already being constructed.

Spain, Mexico, Brazil, Chili, and the Argentine Republic have also decided to join in the work at the Observatories of San Fernando, Tacubaya, Rio de Janeiro, Santiago de Chilé, and La Plata; and, according to their representatives' opinion, Austria and Australia will certainly co-operate at the Observatories of Vienna, Sydney, and Melbourne. The Oxford University Observatory has also decided to take part in the work.

The necessary instruments have been ordered for nearly all these observatories.

Spectroscopic Astronomy in 1887.

The O-Gyalla Catalogue.—The second part of the eighth volume of the *O-Gyalla Observations*, which has been recently published, is devoted to a catalogue of the stars of the zone lying between the equator and the fifteenth parallel of south declination, the character of the spectrum of each star being briefly indicated. This catalogue is intended as a continuation of the spectroscopic survey of the northern heavens projected some years ago by Professor H. C. Vogel and Dr. Dunér; and the same classification of stellar spectra has therefore been followed, and the same limit—viz. mag. 7·5—adopted for the faintest stars to be observed. The first instalment of the northern survey appeared in the third volume of the *Potsdam Observations*, and included 4,051 stars, the zone observed lying between Decl. $+20°$ and Decl. $-1°$. The present catalogue contains 2,022 stars, the great majority being of types Ia and IIa. Only three specimens of type IIIb were found, and but one spectrum was suspected of showing bright lines. Four stars, β, δ, ϵ, ζ *Orionis*, are stated to be variable as to their spectra, but the details of the observations are not given.

Identification of Elements in the Solar Atmosphere.—Professor Trowbridge and Messrs. Hutchings and Holden have published during the year, in the *Proceedings of the American Academy of Arts and Sciences* and elsewhere, a series of short papers on the comparison of the spectrum of the Sun with those of various terrestrial elements. The comparisons were made by means of photography, a large concave grating, by Rowland, of more than 20 feet focus, being used to give the spectra. The first spectrum to be compared with that of the Sun was that of air. With the high dispersion employed, the "bright bands" which Dr. H. Draper believed he had detected in the solar spectrum disappeared, or no longer appeared as such, and all apparent connection between them and the lines of oxygen, with which Dr. Draper had identified them, disappeared also. In place of the bright bands numerous dark lines were seen, but neither did these correspond to the oxygen lines, and Professor Trowbridge's conclusion is that, "so far as concerns the spark spectrum in air, and the solar spectrum from λ 3749·8 to λ 5033·85, we can safely affirm that there is no coincidence between them."

With regard to carbon, on the other hand, Professor Trowbridge concludes that there is positive evidence in the solar spectrum that it exists in the Sun. He regards the fluted spectrum of carbon as an example of the reversal of the lines of a vapour in its own vapour, and he states that he has found a remarkable number of coincidences between the dark lines in the solar spectrum on the one hand, and the dark interspaces separating the successive bright lines of the carbon flutings—not

the bright lines themselves—on the other; and he infers that the temperature of the Sun's atmosphere, at the point where carbon is volatilised so as to produce these reversals, approximates to that of the voltaic arc.

With regard to the spectra of metals, Messrs. Hutchings and Holden believe that they have found good reason for regarding as probable the existence of platinum in the solar atmosphere, sixteen coincidences having been detected between λ 4250 and λ 4950. They confirm the presence of bismuth, cadmium, and silver, which other observers have considered probable, but regard the coincidences in the cases of cerium, lead, molybdenum, uranium, and vanadium as insufficient in number and definiteness to establish their presence in the solar atmosphere.

The Spectra of Meteorites.—The department of astronomical spectroscopy in which the most entirely novel results have been obtained during the past year has been that of the study of meteorites. A lengthy and important paper on the results of his examination of meteoritic spectra under various conditions, particularly that of feeble temperature, was read by Mr. Lockyer before the Royal Society on November 17, 1887. His experiments had shown him that it was possible to obtain spectra from meteorites which should reproduce, more or less perfectly, the most peculiar features of almost every variety of spectrum presented to us by the celestial bodies. In the spectra of nebulæ, for instance, seven lines have been detected, of which three were traced to hydrogen, three to low temperature magnesium, and the seventh, which has not yet been traced to its originating element, has been given by the glow from the Dhurmsala meteorite. The most characteristic nebular line was identified with the low temperature fluting of magnesium, and the unusual spectrum obtained from the comets of 1866 and 1867 was ascribed to the same cause. The changes observed in the spectrum of the great comet of 1882 were such as would correspond to the changes induced by change of temperature in the spectrum of a meteorite, and the changes in the spectrum of *Nova Cygni*, and the bright lines in such a star as *R Geminorum* received a similar explanation; whilst a very full, in parts almost a perfect, reproduction of a considerable portion of the solar spectrum has been obtained by taking a composite photograph of the arc spectrum of several stony meteorites, chosen at random, between iron meteoric poles. These and similar observations have led Mr. Lockyer to regard "all self-luminous bodies in the celestial spaces" as "composed of meteorites, or masses of meteoritic vapour produced by heat brought about by condensation of meteor swarms due to gravity," so that "the existing distinction between stars, comets, and nebulæ rests on no physical basis;" all alike are meteoritic in origin, the differences between them depending upon differences in temperature, and in the closeness of the component meteorites to each other. Novæ are explained as produced by the clash of meteor-streams, and most variable

stars are regarded as uncondensed meteor-streams. Stars with spectra like that of *α Orionis* are considered, not as true suns, but as mere "clouds of incandescent stones, . . . probably the first stage of meteoritic condensation," stars with spectra of the first and second types representing the condensed swarm in its hottest stages, whilst spectra of Secchi's fourth type indicate an advanced stage of cooling.

The Spectrum of Hydrogen, Oxygen, and Water-vapour.—Professor Grünwald, of Prague, has propounded a theory, according to which the wave-lengths of the lines due to a certain element in a given compound are to the wave-lengths due to that same element, when the first compound is combined with some further body, as the volume the element occupies in the first case is to the volume it occupies in the second. Examining the low temperature spectrum of hydrogen, he finds that the wave-lengths of its several lines are just double those of the lines of the water spectrum, line for line. Similar but less simple relationships are given for other spectra, and Professor Grünwald concludes from them that hydrogen and oxygen are compound bodies, and are dissociated in the Sun. Hydrogen is inferred to have a composition of the form a_4b; of which the supposed element a is associated with the line of the corona, 1474 K; and b with the "helium" line, D_3.

Determinations of Wave-lengths.—An exceedingly careful determination of the wave-lengths of the D_2 line of sodium has been recently made by Mr. Louis Bell, Fellow of the Johns Hopkins University. The result is to increase by about one-fifth of a tenthmetre Thalén's correction of Ångström's value; the wave-length finally adopted being 5896·08 tenthmetres with a probable error of about 1 part in 250,000. Professor Rowland has followed this by a table of the relative wave-lengths of about 450 standard lines, based upon the above determination of Bell's, and designed for use in connection with his photographic map of the normal spectrum, to determine the error of the latter at any point.

Photographic Study of Stellar Spectra.

The first annual report of the Henry Draper Memorial appeared during the past year under date March 1, 1887, and gave evidence of an employment of photography so skilful and successful as to open up quite a new prospect in the study of stellar spectra. About a year earlier Mrs. Henry Draper had intimated her intention of providing the means for carrying on at the Harvard College Observatory, as a memorial to her late husband, researches similar to those in which he had been engaged during the last years of his life. Professor Pickering undertook the direction of the work, and a threefold programme

was commenced. First, the spectra of all stars of the sixth magnitude and brighter, from the north pole down to south declination 24°, were to be photographed, and a complete catalogue formed from the measurement and reduction of the plates. Secondly, a similar but more extended catalogue was to be prepared, embracing all stars down to the eighth magnitude. And lastly, the spectra of the brighter stars were to be studied in all possible detail.

Up to the date of the report three telescopes had been employed in the work, viz. an 8-inch Voigtländer photographic lens, Dr. Draper's 11-inch photographic refractor, and, more occasionally, the 15-inch refractor of the Harvard College Observatory. The first two had been employed during the first part of every clear night, but Mrs. Draper, seeing how important in themselves and how promising for future achievements were the results obtained, has proposed to devote two additional telescopes —reflectors of fifteen and twenty-eight inches aperture respectively—to the work, and to provide means for at least three of the telescopes being kept in constant use during the whole of every clear night. And not only has observation thus been arranged for; Mrs. Draper likewise has taken care that the photographs should be measured and reduced, a considerable force of computers being employed for the purpose, and the publication of the results in a suitable form has been provided for.

The spectra obtained so far have been produced by reverting to Fraunhofer's method and placing a large prism before the object-glass. Four large prisms of 15° were produced by splitting a thick plate of glass diagonally. In forming the two catalogues the Voigtländer lens of eight inches aperture has been used, and the spectra of all the stars over a region 10° square were obtained at once upon a single plate. As formed on the plate the spectra were of course but mere lines, but by adjusting the prism with its edge parallel to the equator, and by giving a motion to the driving clock somewhat different from that necessary to make the telescope follow a star precisely, any desired breadth might be given to the spectra. For equatorial stars the exposure for the first catalogue, that of stars down to the sixth magnitude, lasted for five minutes, and the average breadth of the spectrum was 1^{mm}. For the catalogue of fainter stars an exposure of an hour was given. The length of the spectrum was about 12^{mm} for the brighter and 6^{mm} for the fainter stars, the distance between the H and K lines being about one-third of a millimetre. At the date of the report the first cycle, covering the entire sky from zero to twenty-four hours of right ascension, had already been completed and sixty-four plates had been taken in the second cycle. In all, photographs of 15,729 stellar spectra had been obtained, identified, and measured, in the space of a few months. Such an achievement affords a most striking illustration of the potency of the weapon for research which dry-plate photography has placed in our hands. To have secured the

same result by means of direct observation would have required the united efforts of several observers for a succession of years, whilst the fainter spectra would for an equal aperture have been beyond the grasp of the keenest eye to study in detail.

But it is the results obtained under the third head of the programme—the detailed study of bright spectra—which have excited the greatest wonder and admiration. For these the 11-inch refractor has been employed, and one, two, three, or even four prisms have been used before the object-glass. A beautiful spectrum of *Pollux*, for instance, was obtained with the full dispersion in fifty minutes. The distance between H and K on this plate was about four-and-a-half millimetres, and the lines were shown with great distinctness, so that the spectrum easily bore enlarging five times as regards its length, and therefore as regards its dispersion. By the use of a cylindrical lens close to the enlarging lens the breadth of the spectrum was not only increased to four inches, but a number of defects, similar in appearance to the "dust lines" in an ordinary spectroscope, were removed. The specimens of stellar spectra enlarged in this manner which have been prepared by Professor Pickering, and some of which he has presented to this Society, are shown on a scale but one-third less than those used by Ångström and Cornu in the construction of their charts, and the lines are rendered with a clearness and definiteness which would be creditable in a photograph of the solar spectrum. Such results will render it possible to discuss the details of stellar spectra with a minuteness which but a little while ago could scarcely have been hoped for. Amongst some of the more interesting details already brought out may be mentioned the discovery of a series of bright lines in the spectra of the interesting long period variables *Mira Ceti* and *T Orionis*, which appear to correspond to the two violet lines of hydrogen and to four of the dark lines discovered by Dr. Huggins in his photographs of spectra of the *Vega* type. H and K were, however, shown as dark lines in these two stars.

The programme for the future, as laid down in the report, embraced the study of the fainter spectra, particularly those showing shaded bands or bright lines, and those of variable stars, by means of a spectroscope, in which a concave lens replaces the slit and collimator, used in conjunction with the 28-inch reflector. The spectra of the brighter stars were to be classified, and the wave-lengths of their lines determined; comparisons were to be made with terrestrial spectra, and the displacements of the stellar lines due to motion in the line of sight determined. And it is hoped that the work may not have to be confined to the northern hemisphere, but that, by the establishment of a station to the south of the equator, it may be extended to every part of the heavens.

Schiaparelli's Observations of Mars in 1882.

After a long delay the detailed account of Professor Schiaparelli's observations of *Mars* during the opposition 1881–82 has appeared in the *Atti della Reale Academia dei Lincei.* A preliminary notice appeared in 1882 in the *Transunti* of the same Academy, and created considerable sensation by the announcement of the duplication of many of the so-called canals. The present memoir is drawn up and arranged exactly like the two previous ones on the observations made in 1877 and 1879. The measures of the position-angle of the northern polar spot made in 1882 furnish a result for the position of the north pole of *Mars* in space which agrees very closely with the results from the two previous oppositions. Next follow the descriptions of the various surface markings as seen in 1882, the resulting map being given as formerly on Mercator's projection. In general the more prominent markings on the map agree with those on the map of 1879, the most notable difference being the region about the northern end of the *Syrtis Major* (*Kaiser Sea*), where a new dark band, concave towards the south, appeared north-west of *Nilus*, while the *Coloe Palus*, north-east of the *Syrtis*, was not seen. This region has also by other observers been seen to undergo temporary changes or obscurations—*e.g.* by M. Perrotin in 1886 (*Bull. Astron.* July 1886).

The principal interest attached to the memoir is the full account it gives of the remarkable duplication of many of the canals in 1881–82, which on its first announcement was received with much scepticism. Thirty duplications took place between 1881, December 19, and 1882, February 22, of which nineteen were cases of a well-traced and parallel line being formed at a distance of from 4° to 10° or 12° from a previously existing canal, while the remaining were less certainly established or were cases where the lines were not quite parallel. After describing in detail the principal cases the author remarks that the phenomenon seems to be of a periodic character. In 1877 no traces of duplication were seen during the weeks which preceded or followed the southern solstice of *Mars*, which occurred twenty-one days after the opposition. A single case was seen in 1879 on December 26, shortly before the vernal equinox of the northern hemisphere (January 21, 1880), when the *Nilus* appeared double. The very same phenomenon occurred o January 11, 1882 (this time five weeks after the vernal equinox), and remained visible until the end of February, while, as already mentioned, several other duplications had already taken place during the latter half of December. At the opposition of 1884 Professor Schiaparelli observed similar duplications in January, February, and March, the vernal equinox having occurred on October 26, 1883, while the next northern solstice fell on May 13, 1884. Finally in 1886 the greater part of the duplicate

canals had disappeared, and only one long one was seen at Milan and at Nice, while some others were traced with more or less certainty. The northern solstice fell on March 30. Prof. Schiaparelli therefore concludes that the phenomenon of duplication is connected with a period corresponding to the tropical year of *Mars* and depending on the seasons; that it commences to show itself about the vernal equinox, the greater number of cases appearing in the second month after this equinox; and that it disappears again gradually until hardly any remain near the time of the northern solstice. It is as yet impossible to say whether anything similar takes place during the autumn of the northern hemisphere. It is pointed out that a tendency to duplication is also shown in other and better-known features of *Mars*, such as the *Mare Cimmerium* (the eastern half of *Maraldi Sea*) and the *Sinus Sabæus* (*Herschel II Strait*), and the circumstance that these phenomena were in 1886 confirmed by other observers (at Milan by Celoria, and at Nice with a 15-inch refractor by Messrs. Perrotin, Trépied, and Thollon) is referred to as making it impossible to deny their reality, however difficult they may be to explain. J. L. E. D.

The Liverpool Astronomical Society.

This Society, which came into existence only a few years ago by the union of some ten amateur observers, determined to foster a liking for astronomy, especially among the possessors of small telescopes, has been so eminently successful that it now numbers nearly 600 members, and has just published the fifth volume of its transactions.

To promote systematic work in different branches of astronomy, sections have been formed, each under a responsible head, for the separate study of the Sun, Moon, planets, double stars, &c. By this means important observations are brought together and published, which might otherwise remain lost in the notebooks of the observers.

The volume under consideration, as well as those that precede it, contains a large amount of valuable observations, which form a measure of the useful work the Society is accomplishing. A series of papers by Mr. Elger, on "The Moon Surveyed in Common Telescopes," illustrated with sketches of portions of the lunar surface, is an interesting contribution to the subject, and numerous papers on Planets, Meteors, Double Stars, and other branches of observational astronomy indicate the activity with which the Society is pursuing its excellent object.

The Almucantar.

Vol. xvii. of the *Annals of Harvard College Observatory* consists of an account of Mr. S. C. Chandler's new instrument,

the "almucantar," and of its use during a year in observation. In the shape described the almucantar is a zenith telescope of 3·97 inches aperture and 43·8 inches focal length. It differs from the usual form in that instead of being watched by spirit levels, which serve to determine the departure of its axis from its intended direction, the telescope is supported by a float resting in a mercury trough, which in turn is supported on the approximately vertical pillar. Thus when clamped in altitude the line of collimation describes a true small circle of altitude, subject only to a very small correction which might for practical purposes be almost neglected.

The telescope is furnished with a system of cross lines ruled on glass and placed in the focus; in order that a suitably high power may be used these are necessarily very close, and as the mode of observation is entirely by transit over the wires (and mainly over the horizontal ones), a chronograph becomes a necessity. The author of the volume, who is also the inventor of the instrument, gives full details of the adjustments and of the theory of the instrument, so that anyone who may desire to use it will have the means of entering on its study with a safe guide to success. The reductions of a portion of the observations are ample as types, while the results serve as a measure of its value.

There can be no doubt that when the necessary skill has been acquired the instrument is capable of giving results of a very high order of accuracy. Mr. Chandler has applied it to the determination of latitude and time from assumed places of stars, and then investigates the places of a number of stars contained in Auwers's Fundamental Catalogue. The advantage of the instrument for such a purpose is that the results are entirely free from all error arising from flexure, defects of pivots, errors of micrometer screws, &c., and those arising from refraction are practically eliminated. Thus the errors are of a different nature from those of the meridian instruments in ordinary use, and it appears suitable for affording a check on their results. In fact, Mr. Chandler has deduced from his observations what become corrections to Auwers's Catalogue, and in Right Ascension he shows that the almucantar gives in a great majority of cases, when the corrections are at all sensible, similar results to those from recent Greenwich work. It may be doubted whether this instrument, involving as it does the disuse of the micrometer, and requiring to be allowed to settle after setting to the computed place of an object, will be as convenient for geographical work as the older form of the zenith telescope; but, especially in the improved form proposed at the end of the volume, it seems likely that it will be used to check the results of meridian observations of stars, and lead to a more satisfactory knowledge of systematic errors of catalogues.

There is much interesting discussion of practical questions which will repay the reader, but which it would require too much space to describe adequately.

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